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SUPPORT FOR A SHAFT THAT BREAKS WHEN AN IMBALANCE APPEARS

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List of the documents cited in the preliminary search report:	Refer to the end of the present specification

SUPPORT FOR A SHAFT THAT BREAKS WHEN AN IMBALANCE APPEARS

[Support d'arbre cassant à l'apparition d'un balourd]

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Description /1*

The invention concerns a support for a shaft that breaks when an imbalance appears.

It can be used, for example, in turbo reactors and particularly for the shaft which sets a blower into rotation. The blower is intended to accelerate air which enters into an external jet/path of flowing gases, which joins the normal path of flowing gases, which is occupied by the compressors, the combustion chamber and, after the latter, the turbines, to increase the rate of dilution of the gases. The external path is concentric to the normal path and surrounds it. It results from this construction that the vanes of the blower have to be sufficiently elongated to

* [The numbers in the right margin indicate the pagination of the original text.]

extend in front of the external path, which results in a considerable increase in the mass and inertia of the blower. If one of the vanes breaks, a pronounced imbalance appears on the shaft which supports the blower, and thus cyclic stresses and vibrations [are produced] which the support bearings of the shaft of the blower communicate to the fixed parts of the machine with high risks of deterioration.

One could prevent these risks by reinforcing the structure of the machine, but this is not permissible, because one of the principal objectives of the builder is, on the contrary, to make this structure lighter.

Another solution consists in supporting the exposed shaft so it transmits the imbalances through sufficiently weak links that break as soon as an abnormal load appears; the shaft and /2
the piece which it supports then separate from the rest of the machine and slowly slow down.

An example of a breaking support of a shaft bearing is described in US Patent No. 5 417 501, but it involves rupture by shearing and by bending of connecting bolts which connect the support to the fixed structure, by direct transmission of the radial force originating from the imbalance of the shaft, which is not entirely satisfactory because the stresses that are actually transmitted to the breaking bolts are relatively sensitive to the actual assembly conditions and to the actual dimensions of the assembly pieces, which results in a relatively high uncertainty. The invention relates to an improved device comprising breaking elements, whose essential quality is that the force required to produce the rupture is better known; it can be implemented in two different ways which are closely related, because the rupture of the breaking elements is always produced by traction.

In both cases, the invention concerns an arrangement of a rotating shaft which bears an attachment at its front end and thus extends to the back from the attachment; the shaft is supported by a first bearing to the back of the attachment, which is supported by an envelope surrounding the shaft and extending to the back of the last bearing to a stator structure, to which it is joined.

In the first design of the invention, the envelope is clamped to the stator structure by screws that are parallel to the shaft, and these screws comprise, between their head and their threading, a portion with reduced cross section which serves to initiate the rupturing while traction is applied; whereas, in the other design, the envelope presents a circular portion /3
with reduced cross section close to the stator structure to serve as a start of the rupturing.

In the first design, the forces produced by the imbalance and transmitted through the envelope which carries the bearing make it possible to break the screws, whereas in the second design it is the envelope itself which breaks due to the effect of these forces. However, the elongation of the envelope in the direction of the axis of the shaft always allows the conversion of the radial forces produced on the bearing by the imbalance into axial forces at the opposite

end of the envelope. Thus, they are indeed traction forces which are applied to the screw and the adjacent portions of the envelope.

These notations will become clearer in the light of the following figures, which describe some embodiments of the invention as examples and allow one to discover other aspects of the latter:

· Figure 1 is a view of a portion of a turbo reactor illustrating the location of the invention,

· Figure 2 is a general view of the invention,

· Figures 3 and 4 illustrate a breaking screw,

· Figure 5 illustrates another breaking screw,

· Figure 6 illustrates a third breaking screw,

· Figure 7 illustrates another type of embodiment of the invention,

· Figures 8 and 9 represent means to limit the course of the released shaft and of the oil recovery devices,

· Figure 10 represents a mechanism to stop the rotation of the envelope,

· and Figure 11 represents another mechanism to stop the rotation of the envelope.

Let us first look at Figure 1, which is intended to give an idea of the location of the invention in a turbo reactor, in front of a line of low pressure shafts 1, and more specifically on a /4
shaft of a blower, 2, which is mounted on a front bearing 3 and a back bearing 4. The shaft 2 of the blower carries at its front end 5, cantilevered in front of the first bearing 3, a blower 6 which is equipped with vanes 5 that extend in front of the inlet of the internal path or principal path for the flow of gases and of the external path 9 which surround the preceding one and through which the dilution air for the gases flows. One can see a low pressure compressor 10 located in the internal path 8 just to the back of the blower 6 and the high-pressure compressor 11 which is engaged deeper into the internal path 8, as well as lubrication pipes 12 and 13, which are associated with pumps—not shown—to eject oil in front of the rollers of the bearings 3 and 4 and thus maintain their operation. These machine elements, which are already known, are not modified by the invention and are thus only indicated as a reminder.

In Figure 2, it is easier to see that the bearings 3 and 4 of the blower shaft 2 are supported by support pieces which are connected to a stator structure 14. More specifically, the support piece of the front bearing 3 presents a long axial elongation between the front bearing 3 and the place of connection to the stator 4 and thus has a nearly cylindrical shape: it will be called an envelope 15 because it surrounds the blower shaft 2. The support piece 16 of the back shaft 4 has a much more pronounced conicity and its shape resembles that of a disk which is hollowed out in its center.

The envelope and the support 16 are connected to the stator 14 by screws 17 and 18, respectively, for clamping on, and while the screws 18 are of the usual type, the screws 17 are an essential part of the invention, as can be seen better in Figure 3.

Their threading 19 is engaged in an internal threading of the stator 14 and their head 20 /5
rests on a free surface 21 of a flange 22 at the end of the envelope 15. They comprise a smooth part 23 between the threading 19 and the head 20, and this smooth part 23 comprises a weakened part 24, with a reduced cross section, located in the piercing 24 of the flange 22 through which the screw 17 passes. Figure 3 makes it easier to understand, in connection with the preceding figures, that, if one of the vanes 7 is separated from the blower 6, the cyclic radial stress transmitted to the blower shaft 2 and to the front bearing 3 will be converted into a cyclic axial force on the screws 17, which will be broken by traction at the weakened part 24 when this force becomes sufficiently strong. The screws 17 are normally broken one after the other in a single revolution of the blower shaft 2, and this will occur more easily because the overall resistance decreases continuously as the ruptures occur. The envelope 15 will then be separated from the stator 14 and will no longer transfer forces to it.

However, another aspect of the invention needs to be broached, returning for a moment to Figures 1 and 2. In the situation of rupture of the envelope 15, the front bearing 3 has become unable to support the blower 6 and the blower shaft 2 is then no longer supported by the back bearing 4, which in turn starts to transmit the forces.

This is the reason why it is generally preferred to stop this support and thus also separate the back bearing 4 from the stator 14. One can then adopt the solution of Figure 4, in which the support, now bearing the reference numeral 27, of the back bearing 4 is no longer clamped directly to the stator 14 by the screws 18, but to a flange 28 of the envelope 15 close to the flange 22 for the reception of the screws 17. When the latter are broken, the support 27 accompanies the /6
envelope 15.

The front end of the line of low pressure shafts 1 becomes floating, and it can oscillate fairly strongly in the radial direction and possibly rub against the series of high pressure shafts 2 which itself is coaxial and rotates at a much different speed. The lines of shafts 1 and 2 can be damaged. This risk explains that the possibility of leaving the back bearing 4 attached to the stator 14 can nevertheless be retained.

Two principal arrangements can be considered to improve the system of connecting the envelope 15 to the stator 14. In the first arrangement, illustrated in Figure 5, the head 20 of the screws 15 no longer rests on the flange 22 but on a dowel 35 which is threaded around the smooth part 23 of the screw 17 and compressed between the head 20 and the flange 22. In that case one must use a longer screws 17, which, however, is strongly stressed at the beginning and

more flexible, which confers a better resistance to fatigue and a resistance which is estimated with greater precision.

In Figure 6, the screw 17 is replaced by a screw 36 having the same shape, except that it is completed by a base 37 located between the head 20 and the smooth part 23. The base 37 is substantially broader than the head 20 and the base which rests on the free surface 21 of the flange 22, around the piercings 25, which are here substantially broadened compared to the design of the preceding figures.

Indeed, one chooses the diameter of the piercings 25 with a higher value than that of the diameter of standardized screw heads which have the same nominal threading diameter than the screws 36 which one wishes to use. This means that if the assembler by mistake uses /7
standard screws instead of the screws 36, their head would engage in the piercings 25 and it would be impossible to tighten the envelope 15.

Other precautions can be conceived for the screws 17 or 36; thus, one could shape them with a head having a special shape, which would yield as soon an excessive tightening torque would be communicated. In this manner, one would avoid inflicting an assembly prestress to the screws, which would reduce their desired resistance to rupture.

Figure 7, on the other hand, illustrates another design of the invention, where the screws 17 or 36 are replaced by ordinary screws 38. The rupture zone is then located on the envelope itself, which here bears the reference numeral 39, and it consists of a weakened zone 40 located on the envelope 39 between the front bearing 3 and the flange 22, and in proximity to the latter. This weakened zone 40 is circular and it comprises a localized decrease in thickness around the envelope 39. It can also comprise, as shown here, recesses 42 which divide it alternating with connection lamellas 43 for extension which are substantially axial and which connect the solid and thick parts of the envelope 39. One can see immediately that the rupture will occur after an excessive traction has been applied to the lamellas 43 or, more generally, to the entire length of the weakened zone 40, and that the envelope 39 would rupture at this place. The phenomenon will be slightly different from that of the rupture of the screw 17 or 36, because the envelope 39 will be separated almost entirely from the stator 14. In this case, as in the other case, the support 16 or 27 can be connected or not to the envelope 39, and it is this first solution, normally the more advantageous one, which is illustrated here.

However, the solution with breaking screws is probably preferable because the rupture /8
force is determined with greater precision.

Other secondary, but useful, aspects of the invention deserve to be mentioned briefly with reference to the following figures. First, it is possible (Figure 8) to stop the course of the line of low pressure shafts 1 after the rupture if they become excessive. For this purpose, one can mount a rib 47 on the stator 14 around the envelope 15, to contain its movement, or another rib 48, also

fixed to the stator 14 and which ends in one or more skids 49 surrounding the line of low pressure shafts 1 at a small distance from it. These stoppage means are ineffective as long as the bearings 3 and 4 fulfill their role but they prevent movements of excessive amplitude of the line of shafts in the contrary case, in that case functioning as movement limiting parts or backup bearing.

Concurrently, a device for the recovery of lubrication oil can also be mounted on the stator 14, for example, in the form of a scoop 50 illustrated in this Figure 8, which is mounted with a cantilever on the rib 48, or a scoop 51 of greater length, illustrated in Figure 9, which comprises a sleeve 52 which glides on the crowns 53 and 54, respectively, mounted on the stator 14 and the envelope 15. The sleeve 52 thus completely surrounds the envelope 15 and it directs the oil that is projected on it toward a recovery device (not shown) located on the stator 14, thanks to its shape which is tapered toward it. In all cases, the envelope 15 is perforated by orifices in front of the scoop 50 or 51 so that the oil passes through it and leads into the scoop.

Finally, it is advantageous to oppose excessive rotations of the envelope 15 or 39 once it /9
is detached. One solution is illustrated in Figure 10; it consists in hollowing out the flange 22 of the envelope 15 with curled edges 55 between the locations of the screws 17. Care must be taken to install slugs or pins 56 on the stator 14 so that they engage in the curled edges 55 with some tolerance. When the envelope 15 is separated, the slugs 56 abut against the walls of the curled edges 55 and stop it.

Naturally, other stoppage systems can be conceived of, all equally valid, such as those of Figure 1: here a cable 57 is used, whose ends are fixed to the stator 14 and to the envelope 15, respectively. Several of these cables are provided around the envelope 15. The effect is the same as above as soon as the rotation of the envelope 15 applies tension to the cables 57.

Naturally, the different improvements evoked here are normally compatible with all the principal embodiments mentioned, and they can be used additively.

Claims /10

1. Arrangement of a rotating shaft (2) which bears an attachment (6) at one end and extends to the back from the attachment, where the shaft (2) is supported by a first bearing (3) to the back of the attachment and the first shaft is borne by an envelope (15) which surrounds the shaft (2) and extends to the back of the first bearing to a stator structure (14), to which the envelope is clamped by screws (17), which are parallel to the shaft (2), characterized in that the screws comprise between the head (20) and the threading (11) a portion with reduced cross section (24), which serves as a start of the rupturing when traction is applied.

2. Arrangement of a rotating shaft according to Claim 1, characterized in that the dowels (35) for elongation of the screws are threaded around the screws and clamped by the screws (17).

3. Arrangement of a rotating shaft according to any one of Claims 1 or 2, characterized in that the screws are special screws with a base (37), and they are engaged in broader piercings than standard screw heads having the same nominal diameter as said special screws, where the bases rest on bearing surfaces (21) surrounding the openings of the piercings (25).

4. Arrangement of a rotating shaft according to any one of Claims 1-3, characterized in that the envelope is connected to a support of a second bearing (4) supporting the shaft (2) in the back of the first bearing (3).

5. Arrangement of a rotating shaft (2) which bears an attachment (6) at one end and extends to the back from the attachment, where the shaft is supported by a first bearing (3) to the back of the attachment and the first shaft is borne by an envelope (39) which surrounds the shaft (2) and extends to the back of the first bearing (3) to a stator structure (14) to which the envelope (39) is joined, characterized in that the envelope presents a circular portion (40) having a reduced cross section close to the stator structure to serve as a start of the rupturing. /11

6. Arrangement of a rotating shaft according to Claim 5, characterized in that the circular portion comprises a decrease in thickness (41).

7. Arrangement of a rotating shaft according to any one of Claims 5 or 6, characterized in that the circular portion comprises alternating orifices (42) and lamellas (43).

8. Arrangement of a rotating shaft according to any one of Claims 1-7, characterized in that the shaft is surrounded by skids (49) which stop the radial course.

9. Arrangement of a rotating shaft according to any one of Claims 1-8, characterized in that the envelope (15, 39) is connected to the stator structure (14) by means to stop rotation (56, 57).

10. Arrangement of a rotating shaft according to Claim 9, characterized in that a means to stop rotation comprise slugs (56) which are parallel to the shaft.

11. Arrangement of a rotating shaft according to Claim 9, characterized in that the means to stop rotation comprise cables (57).

12. Arrangement of a rotating shaft according to any one of Claims 1-11, characterized in that the scoop (50, 51) for the recovery of lubricant is arranged around the envelope.

13. Arrangement of a rotating shaft according to any one of Claims 1-12, characterized in that the attachment (6) is a turbo reactor inlet blower. /12

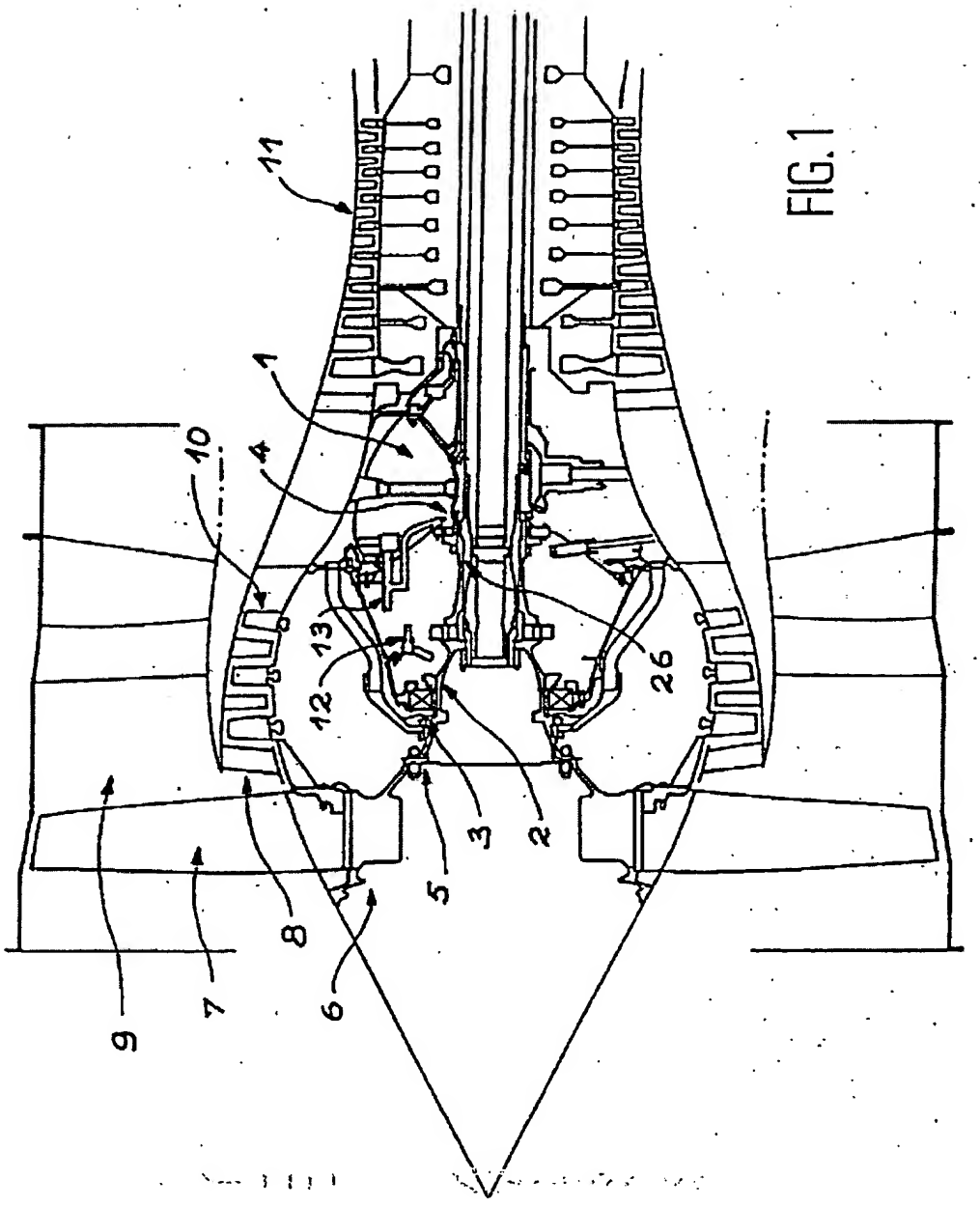

FIG.1

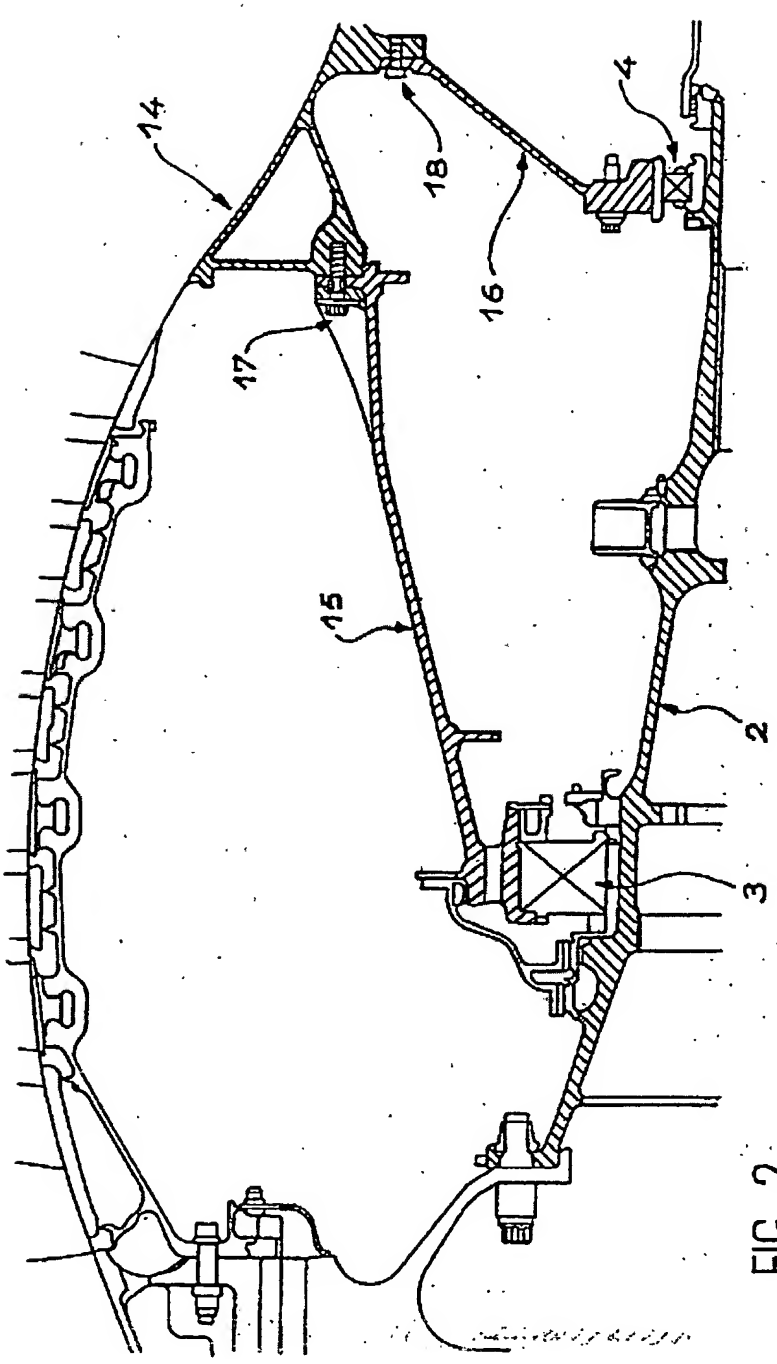

FIG. 2

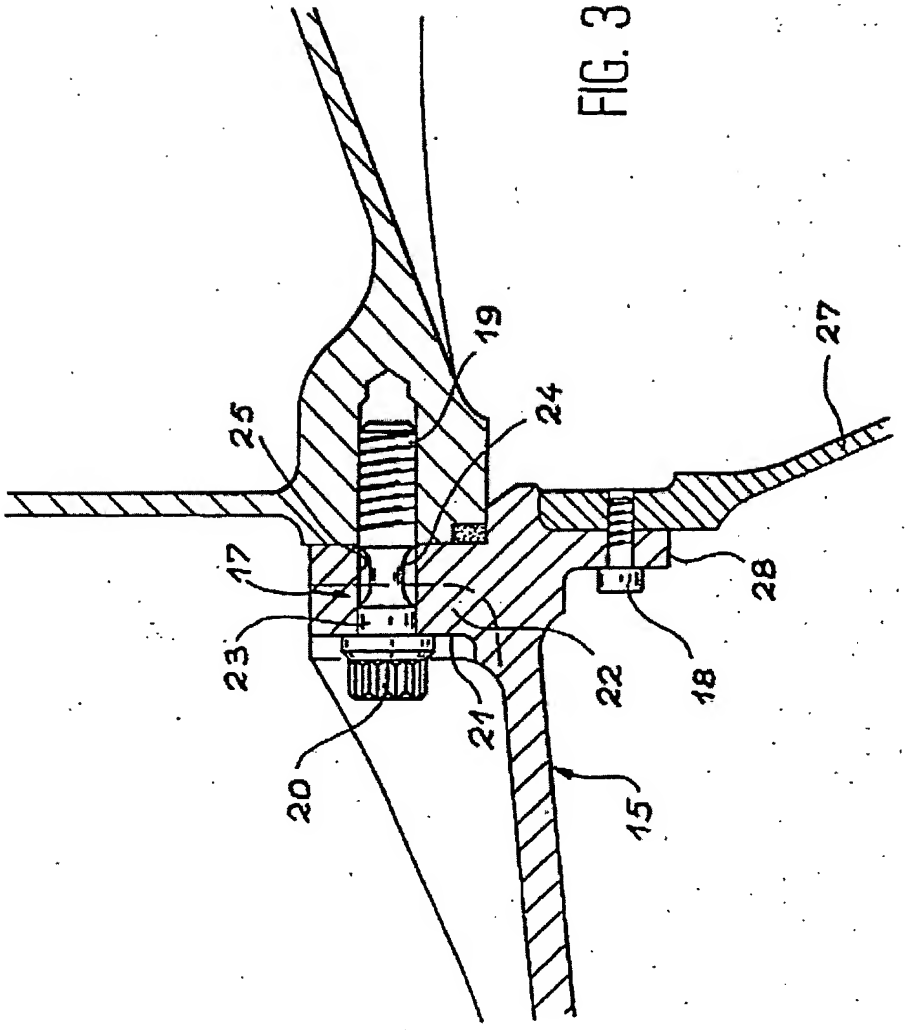

FIG. 3

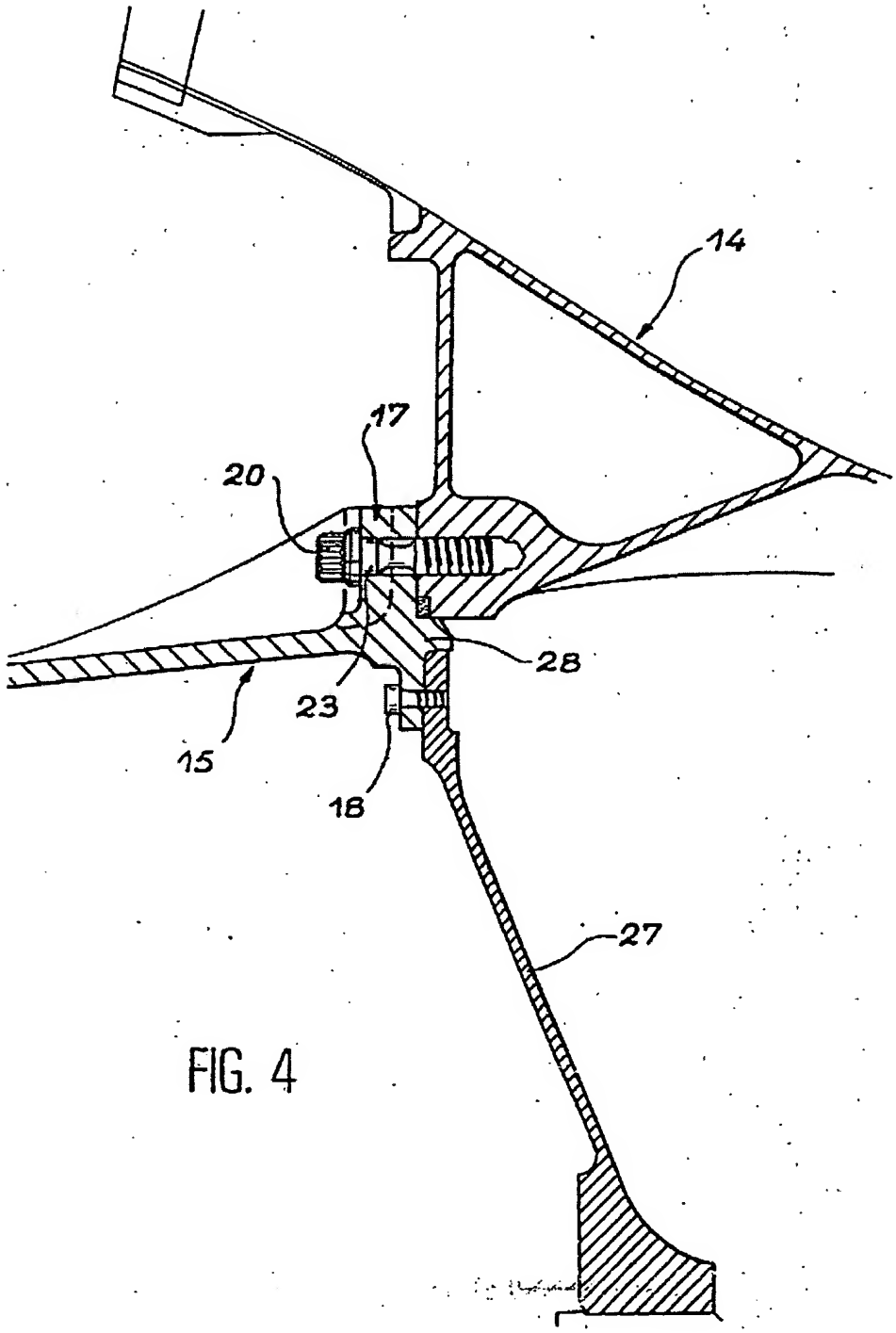

FIG. 4

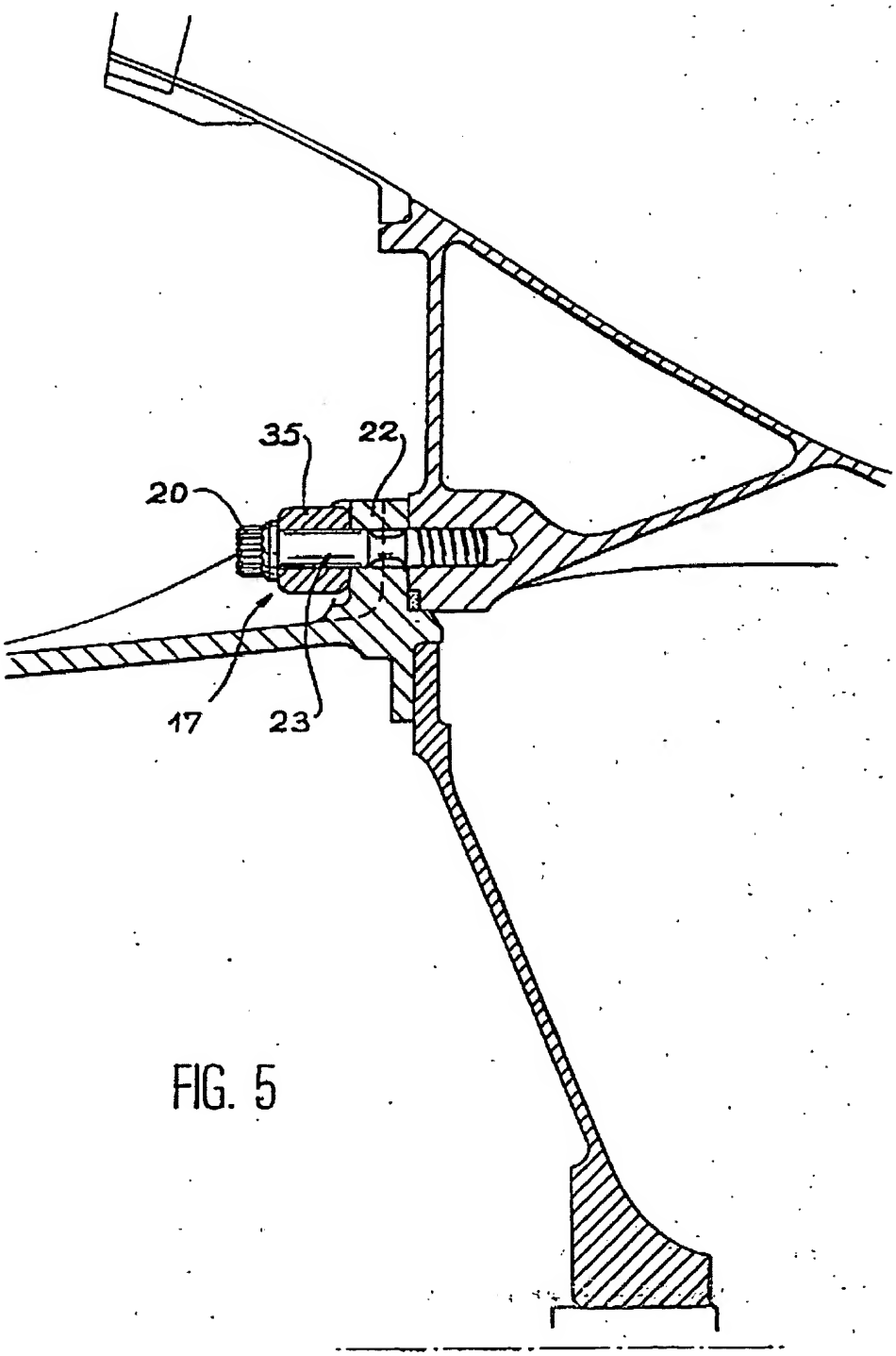

FIG. 5

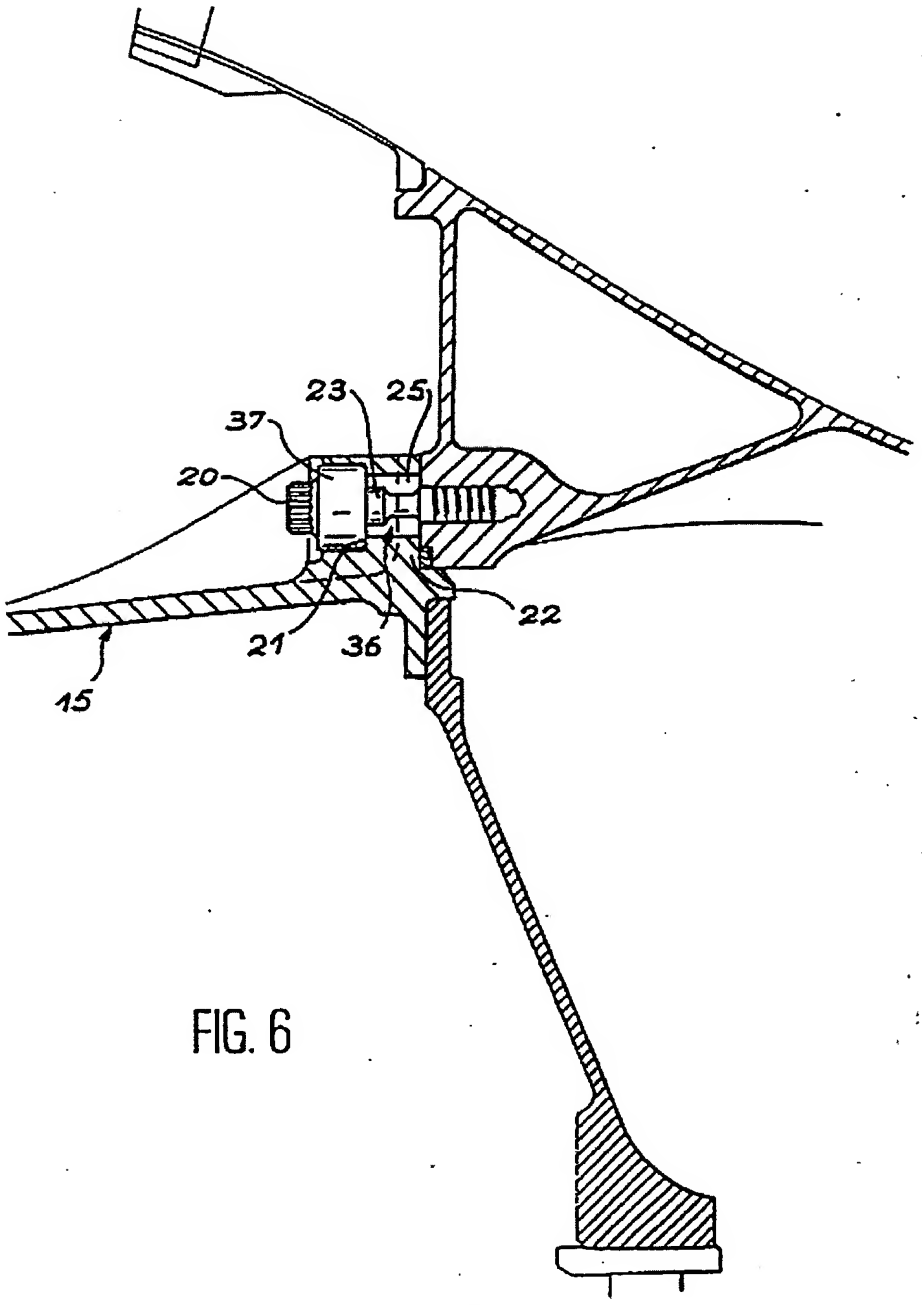

FIG. 6

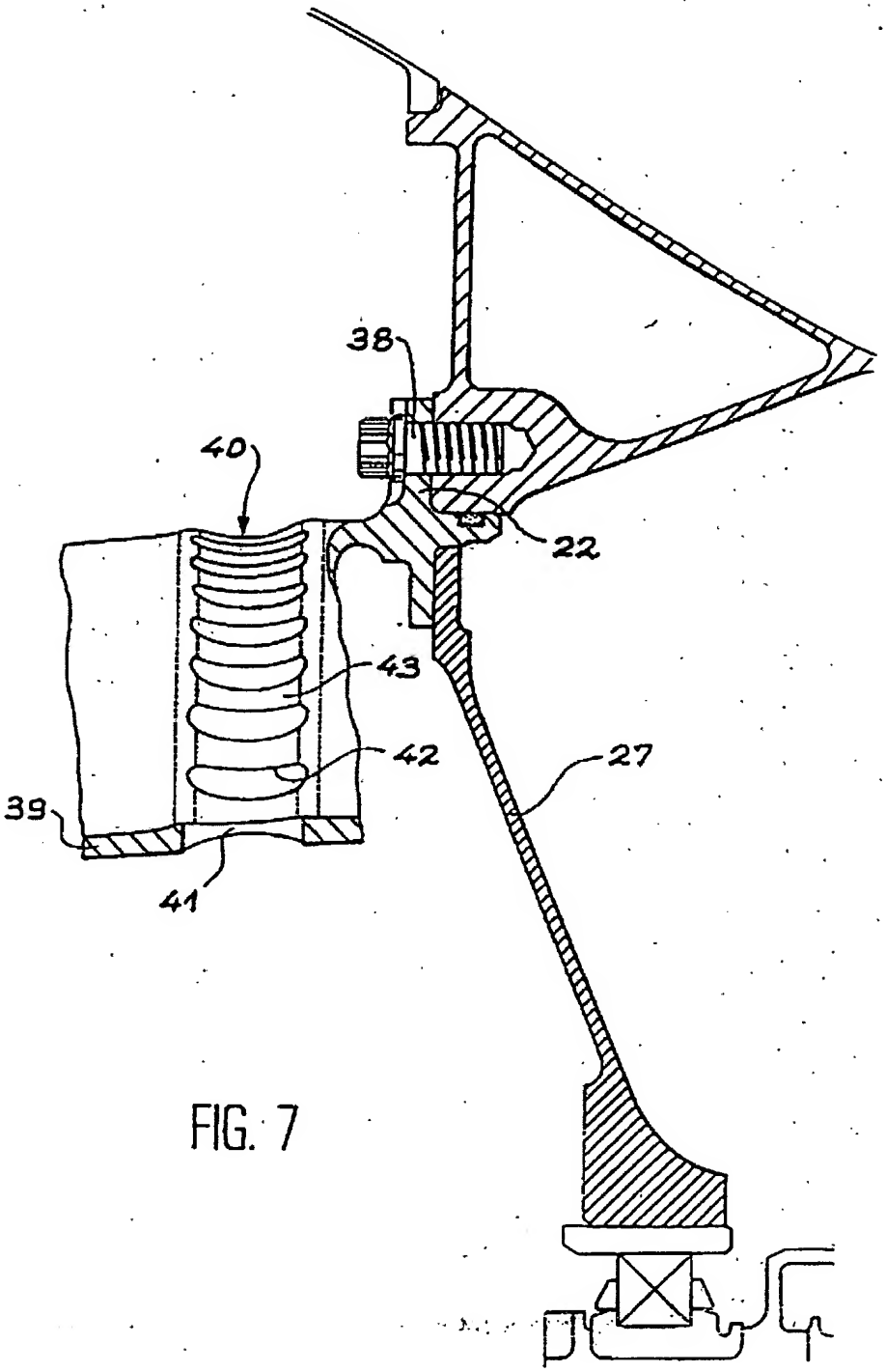

FIG. 7

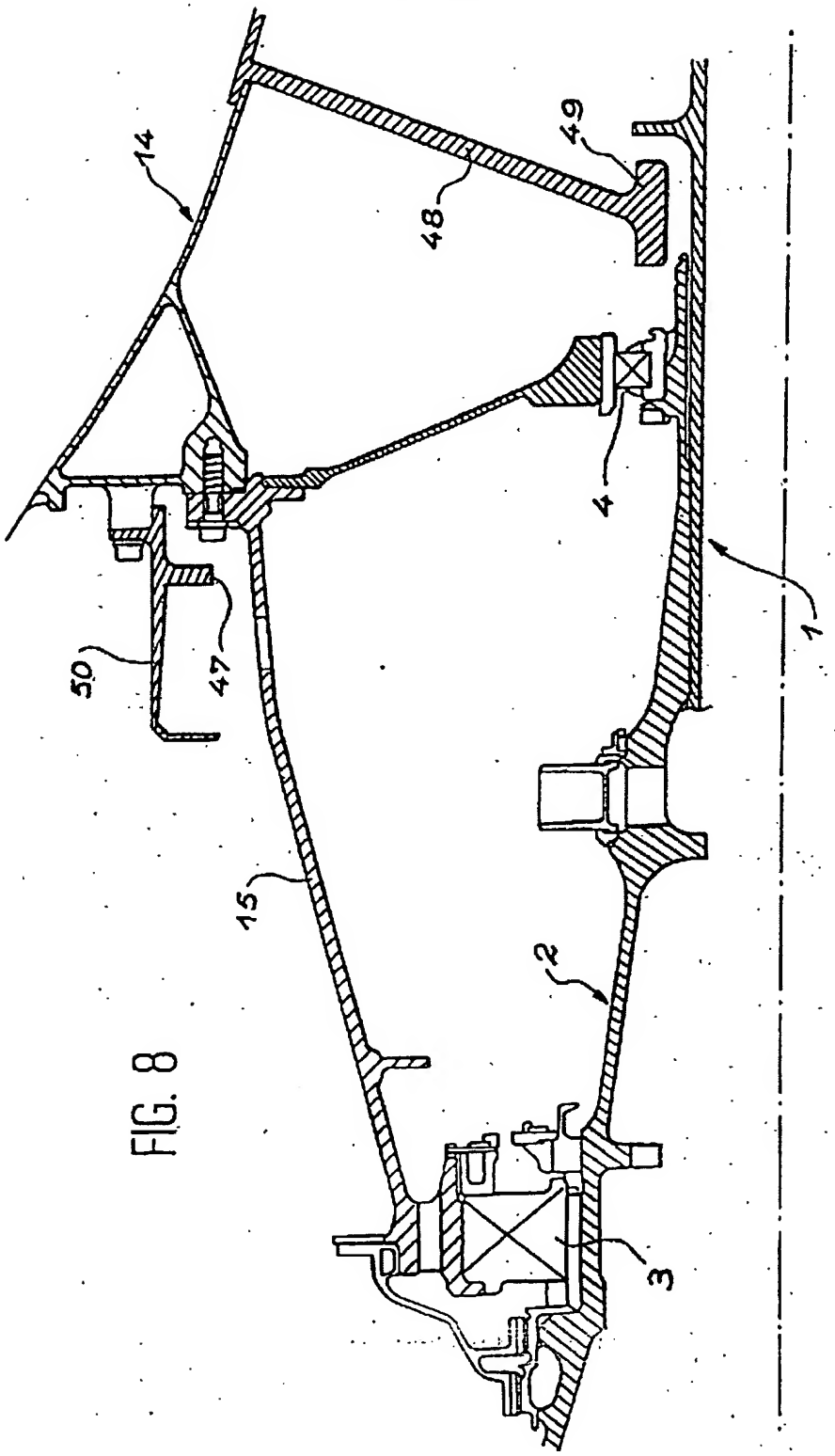

FIG. 8

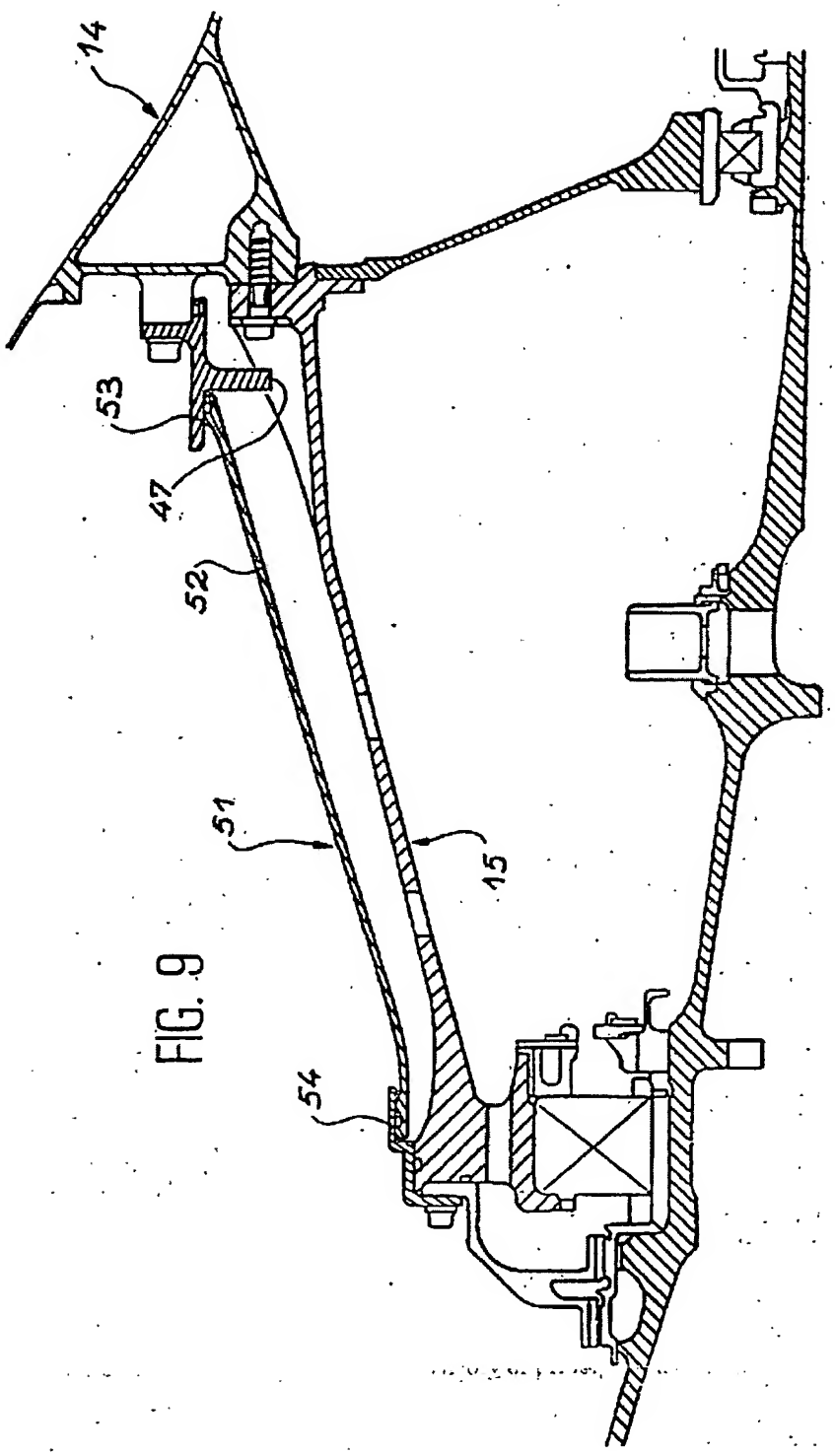

FIG. 9

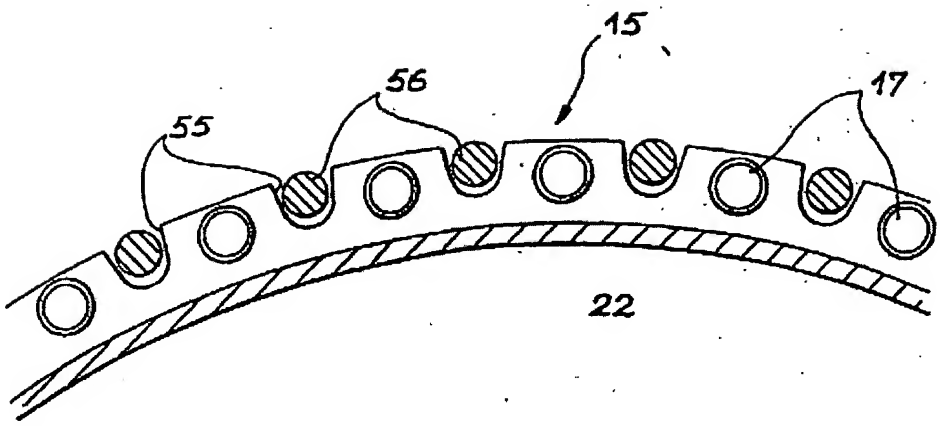

FIG. 10

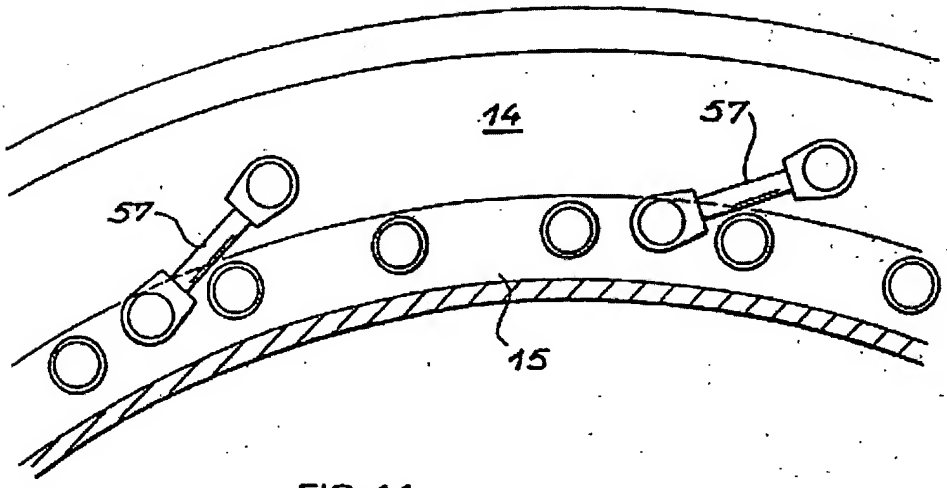

FIG. 11

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PRELIMINARY SEARCH REPORT
established on the basis of the most recent claims filed before the start of the search

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Category	Citation of document with indication where appropriate, of relevant passages		
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Y	DE 33 41 141 A (BBC BROWN BOVERI & CIE) May 23, 1985 * page 7, line 16 – line 20; claim 1; figure 1 *	5-7	

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Date of completion of the search	Examiner
April 24, 1997	Criado Jimenez, F

CATEGORY OF CITED DOCUMENTS

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L: Document cited for other reasons.

&: Member of the same patent family, corresponding document.

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Application Number
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PRELIMINARY SEARCH REPORT
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DOCUMENTS CONSIDERED TO BE RELEVANT		Claims concerned in the examined document	
Category	Citation of document with indication where appropriate, of relevant passages		
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Y	US 5 433 584 A (AMIN MOHAMED-SAMY A ET AL) July 18, 1995 * column 3, line 29 – line 52; figure *	12	
A	GB 1 418 907 A (ROLLS ROYCE) December 24, 1975 * page 1, line 46 – line 49 *	5-7	
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